

EARLY LIFE HISTORY OF THE OYSTER CRAB, *PINNOTHERES OSTREUM* (SAY)¹

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INTRODUCTION

The first and second zoeae of *Pinnotheres ostreum* have been described by Hyman (1924). The five crab stages parasitic in the oyster (*Ostrea virginica*) have been described by Stauber (1945). The present paper is an attempt to complete the knowledge of the development of the oyster crab from the egg to the first crab instar. This work was done at the Virginia Fisheries Laboratory in the summer of 1944, under the direction of Dr. Curtis L. Newcombe.

The first Pinnotherid larva to be described was the zoea of *Pinnotheres pisum* Leach, the British pea crab. This species has three or more zoeae. Other members of the family are said to have two, three or four zoeal stages; in some species a megalops stage has been described, while one at least is said to pass directly from the last zoea to the first crab. The family Pinnotheridae is noted for the great diversity of the zoeae in different species, and this lack of uniformity seems to apply also to the number of larval stages. Faxon (1879) stated that the last zoea of *Pinnixa chaetoptera* molted directly into a first crab stage, without a megalops stage. Smith (1880) found a megalops in another species of *Pinnixa*. There are only two published descriptions of Pinnotherid megalops: *Pinnotheres veterum* by Lebour (1928) and *Pinnotheres taylori* by Hart (1935). In the latter there are two zoeae and one megalops.

The first zoea of *Pinnotheres ostreum* was hatched from the egg by Birge (1878), but he was unable to rear second zoeae. Hyman (1925) obtained the first zoeae of *Dissodactylus mettituae*, *Pinnotheres maculatus*, and *P. ostreum* by hatching, and described the second zoea of *P. ostreum* from specimens reared from first zoeae caught in plankton.

In the present study, all specimens were reared in the laboratory from the egg. *Pinnotheres ostreum* was found to have four zoeal stages and one megalops, followed by the first crab.

METHODS

Ovigerous female crabs were removed from oysters and the egg strands were cut away and placed in shallow enamel pans containing sea water. The salinity of the water used varied from 20 to 26 parts per thousand while the temperature was approximately 23° C.

On July 15, 1944, a medium brown sponge was removed from an oyster crab and placed in water. One week later first zoeae emerged from the eggs. Ecdysis

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of the larval cuticle occurred simultaneously with hatching. Five days later some first zoeae molted to become second zoeae, and three days afterward third zoeae appeared. All of these third zoeae died in ecdysis without becoming fourth zoeae.

A second experiment was begun on July 16, 1944. A younger sponge of bright orange color was placed in hatching pans. First zoeae hatched at the end of twelve days and after three days these specimens became second zoeae. In an additional five days the third instar appeared, and after seven more days several individuals reached the fourth zoeal stage. There was a high mortality rate during this ecdysis. The fourth zoeae were placed in individual glass finger bowls. Six days later one megalops completed a successful ecdysis and became a first crab. Three other fourth zoeae also reached the megalops stage and eventually one of these became a first crab, but the times were not noted. The total time in this experiment, from the recently laid orange eggs to the megalops stage, was 33 days, and the total time required to obtain the first crab was 38 days. The period of larval development, from hatching to first crab, was 25 days.

The length of time spent in each instar during the development seemed to depend on a number of factors, food abundance and water temperature having the most obvious effect. Few complete records on embryonic and larval development of crabs have been published. Hart (1935) found that four or five weeks were required for *Pinnotheres taylora* to pass through two zoeal instars and one megalops stage.

The food used in rearing *P. ostreum* larvae consisted of concentrated plankton from York River. A yellow dinoflagellate was eaten most readily by the zoeae, but they also fed on crab eggs. Excess food was removed after feeding to prevent fouling. Water was changed every second day and was aerated several times daily by pipetting.

In the morphological study of life history stages it was necessary to use the material conservatively, since very few specimens of each stage were preserved. Killing and preservation were in 5 per cent formalin. For study, each specimen was placed in a drop of glycerine on a slide, a cover glass was put on, and the specimen was drawn *in toto* without flattening. Megalops and first crab stages were placed on depression slides to avoid distortion. Cover glasses were removed after *toto* drawings had been made, and the specimens were dissected with ordinary dissecting needles. Appendages were pulled off, not cut. Dissected parts were arranged in the glycerine with needles and the cover glass replaced, with slight pressure. No great difficulty was experienced with this method; in nearly every case at least one member of each pair of appendages was found intact and in position to draw. All drawings were made with a camera lucida; only very fine details such as the setules on feathered setae were added free hand.

DESCRIPTION OF STAGES

First zoca (Figs. 1, 3, 4, 6, 8, 9, 12)

In living specimens, fully extended but not flattened, the total length is 0.90 mm. In formalin-preserved specimens the total length is 0.7 to 0.9 mm. The carapace averages 0.42 mm. in length and 0.27 mm. in width. The eyes are 0.11 to 0.13 mm. in diameter. There are no dorsal or lateral spines on the carapace.

The abdomen has five segments, not counting the telson; its width increases toward the posterior end. The second and third abdominal somite bear short triangular lateral knobs. The telson has three toothlike lobes, with three setae on each side between the lateral and median lobe. The chromatophores are distributed as described by Hyman (1925). The antennules are folded to a spherical form, and bear two large and one small aesthete or sensory hair. The antennae are not visible. The first maxilla (maxillule) has no "epipodital hair"; the protopodite bears a chromatophore; the proximal (coxopodite) lobe bears four setae, the distal (basipodite) lobe has five, and there are four setae arranged in two groups of two each on the two-segmented endopodite. The second maxilla has a chromatophore on the protopodite, five setae on the coxopodite, eight or nine on the basipodite, three on the endopodite, and four on the scaphognathite. The first maxilliped has chromatophores in the coxopodite and basipodite; the basipodite bears eight setae, the exopodite has four long terminal setae or "swimming hairs," and the five-segmented endopodite has one seta on the proximal segment, two on the second, one on the third, two on the fourth, and five on the terminal segment of which four are terminal. The second maxilliped has a chromatophore on the coxopodite, a chromatophore and four setae on the basipodite, four "swimming hairs" on the exopodite, and four setae on the terminal segment of the two-segmented endopodite. No buds of other appendages are visible.

Second zoea (Figs. 2, 10, 13).

The total length of preserved specimens is 1.48 mm., but these specimens have an abnormal swelling between the thorax and abdomen; the normal length would be somewhat less. The length of the carapace is 0.57 mm. The eye is 0.12 to 0.14 mm. in diameter. The first maxilla has an external seta or "epipodital hair," and there are five, seven, and four setae on the coxopodite, basipodite and endopodite, respectively. The second maxilla has six, nine, and three setae on these three endites; the scaphognathite has three apical setae and five near the basal end. The

EXPLANATION OF PLATE I

All drawings made with camera lucida from specimens killed and preserved in 5 per cent formalin, mounted in glycerine. Scale A represents 0.4 mm. in Figures 1, 2, 6, 7, 7a, and 8. Scale B represents 0.1 mm. in Figures 3 and 4.

FIGURE 1. First zoea of *Pinnotheres ostreum*, hatched from egg in laboratory, drawn with $10 \times 10 \times$ lenses.

FIGURE 2. Second zoea of *P. ostreum* reared from egg in laboratory, drawn with $10 \times 10 \times$ lenses.

FIGURE 3. First maxilliped of first zoea, *P. ostreum*, drawn with $7.5 \times 43 \times$ lenses; swimming hairs of exopodite cut off to allow placement of figure on plate.

FIGURE 4. Second maxilliped of first zoea, *P. ostreum*, drawn with $7.5 \times 43 \times$ lenses; swimming hairs cut off figure.

FIGURE 5. Telson of third zoea, *P. ostreum*, drawn with $15 \times 10 \times$ lenses.

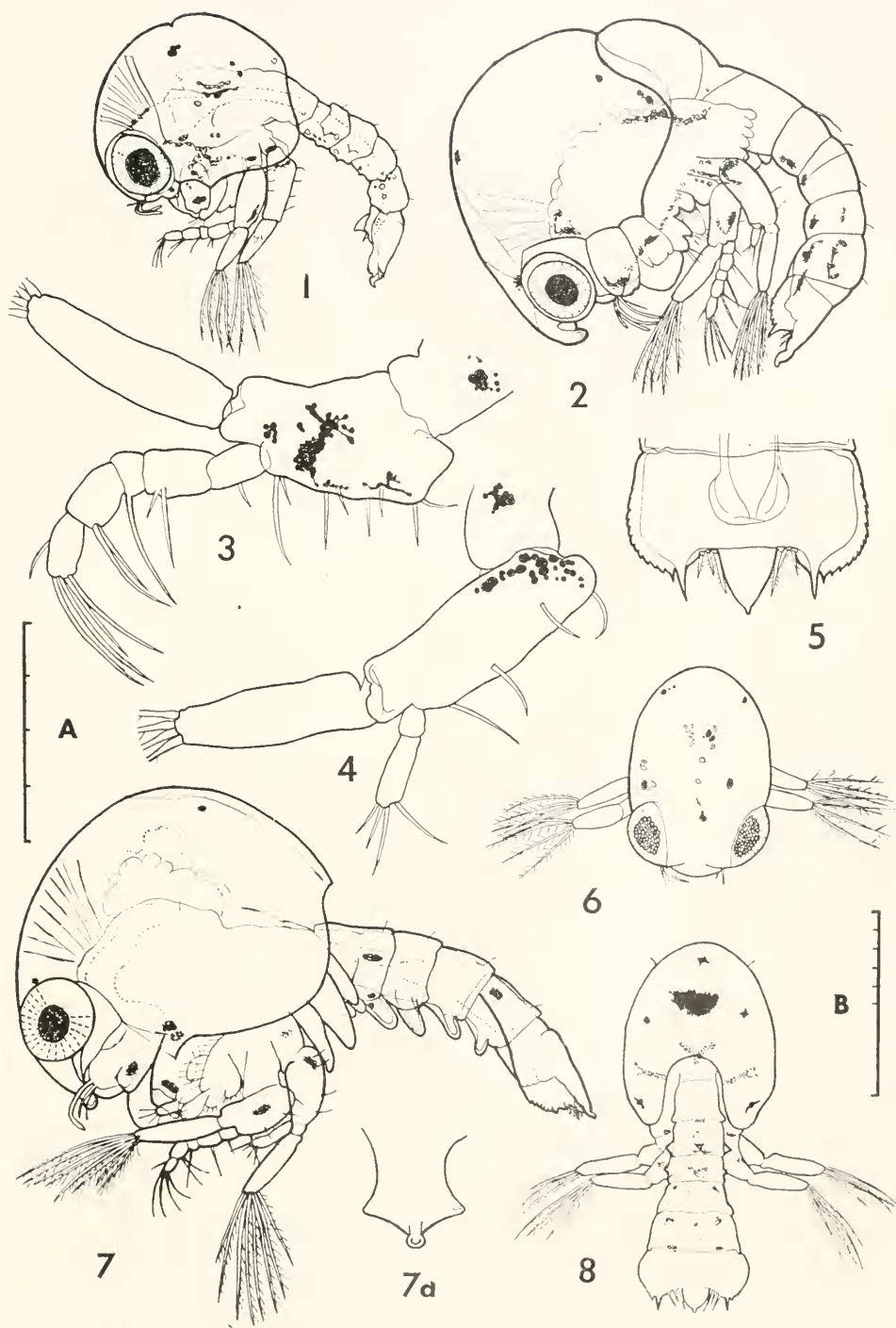
FIGURE 6. Anterior view of first zoea, *P. ostreum*, drawn with $10 \times 10 \times$ lenses.

FIGURE 7. Third zoea of *P. ostreum* reared from egg in laboratory, drawn with $10 \times 10 \times$ lenses.

FIGURE 7a. Rostrum of third zoea, *P. ostreum*, frontal view, drawn with $10 \times 10 \times$ lenses.

FIGURE 8. Posterior view of first zoea, *P. ostreum*, showing dorsal view of abdomen, drawn with $10 \times 10 \times$ lenses.

PLATE I



first and second maxillipeds each have six swimming hairs on the exopodite. Buds of other thoracic appendages can be seen, but there are still no buds on the abdomen. Other features are as in the first zoea.

Third zoea (Figures 5, 7, 7a, 11, 14)

The total length of preserved specimens is 1.3 mm. The carapace is 0.60 mm. long (0.58 to 0.63). The eye is 0.14 to 0.16 mm. in diameter. The antennule bears three large and one small aesthete. The first maxilla has five setae on the coxopodite, eight or nine on the basipodite, and four on the endopodite. The second maxilla has seven to nine setae on the coxopodite, nine or ten on the basipodite, and three on the endopodite; the scaphognathite has five apical setae and eight to thirteen setae between the proximal end and the apical setae. The coxopodite of the first maxilliped has three setae, the basipodite has eight or nine setae, and the exopodite has eight swimming hairs. The exopodite of the second maxilliped also has eight swimming hairs. Buds of the other thoracic appendages are prominent and buds of the abdominal appendages are visible. Other features are as in the first zoea, except for size.

Fourth zoea

Only four or five specimens were obtained, and they molted to become megalops before they could be studied. The only known feature is the possession of ten swimming hairs on each of the maxillipeds.

Megalops (Figs. 15, 16, 17, 18)

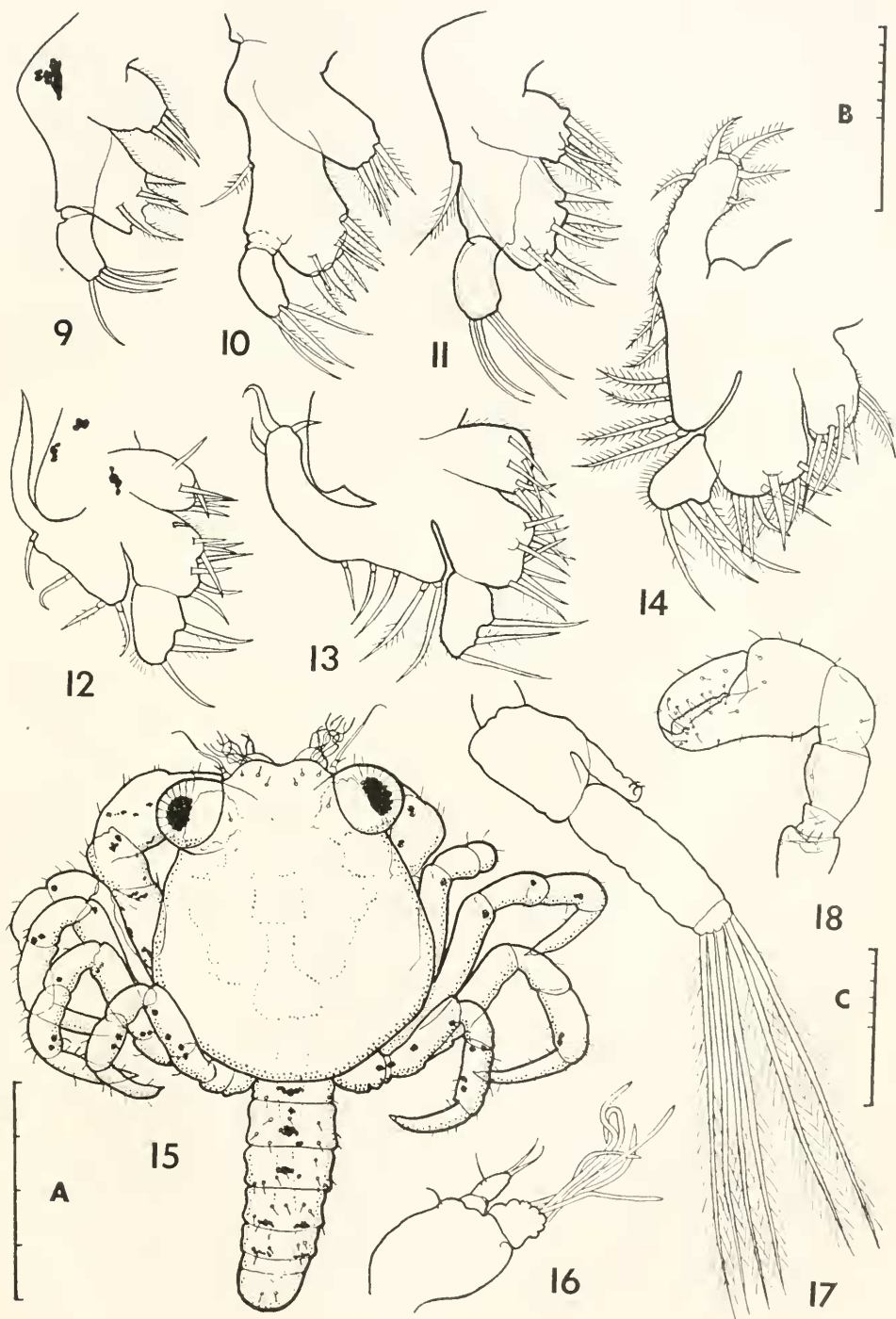
The total length is 1.0 to 1.05 mm. The carapace is 0.60 mm. long and 0.58 mm. wide. The abdomen, extended, is 0.40 to 0.45 mm. long and 0.17 mm. wide across the second segment. The eye is about 0.14 mm. in diameter. The carapace has no spines, on the rostrum or elsewhere, but has four to nine setae along each lateral edge. The fifth leg has no "feelers" on the last segment. The antennule has seven or eight aesthetes on the distal segment (outer flagellum). The antenna

EXPLANATION OF PLATE II

All drawings made with camera lucida from specimens killed and preserved in 5 per cent formalin, mounted in glycerine. Scale A represents 0.4 mm. in Figures 15 and 18. Scale B represents 0.1 mm. in Figures 9, 10, 11, 12, 13, and 14. Scale C represents 0.1 mm. in Figures 16 and 17.

- FIGURE 9. First maxilla of first zoea, *Pinnotheres ostreum*, drawn with $7.5 \times 43 \times$ lenses.
- FIGURE 10. First maxilla of second zoea, *P. ostreum*, drawn with $7.5 \times 43 \times$ lenses.
- FIGURE 11. First maxilla of third zoea, *P. ostreum*, drawn with $7.5 \times 43 \times$ lenses.
- FIGURE 12. Second maxilla of first zoea, *P. ostreum*, drawn with $7.5 \times 43 \times$ lenses.
- FIGURE 13. Second maxilla of second zoea, *P. ostreum*, drawn with $7.5 \times 43 \times$ lenses.
- FIGURE 14. Second maxilla of third zoea, *P. ostreum*, drawn with $7.5 \times 43 \times$ lenses.
- FIGURE 15. Megalops of *P. ostreum* reared from egg in laboratory, dorsal view, drawn with $10 \times 10 \times$ lenses.
- FIGURE 16. Distal portion of antennule of megalops, *P. ostreum*, drawn with $6 \times 44 \times$ lenses.
- FIGURE 17. First pleopod of megalops, *P. ostreum*, drawn with $6 \times 44 \times$ lenses.
- FIGURE 18. Dorsal view of right cheliped of megalops, *P. ostreum*, drawn with $10 \times 10 \times$ lenses.

PLATE II



is five-segmented with a long slender process and a short seta on the distal segment. The abdomen seems to have six segments, but the sixth segment is very indistinct and may be fused with the telson. There are four pairs of pleopods, on the second, third, fourth and fifth segments; the exopods of the first three pairs bear six swimming hairs; those of the last pair have only five. (In the other specimen, the first pleopods have five hairs, the second and third have six, and the fourth have four.)

First crab (Figs. 19, 20, 21, 22, 23)

The carapace is 0.61 mm. long and 0.59 mm. wide. The diameter of the eye is about 0.14 mm. There are no spines on the carapace, but each lateral edge bears seven to nine setae. The last two segments of the third and fourth legs bear long plumose setae, but there are no "feelers" on the fifth leg.

It should be noted that these two laboratory-reared specimens are considerably smaller than the "first stage females" of Stauber (1945). Stauber used this name for the youngest females which invade the oyster, evidently not intending to imply that they were in the first crab instar. Probably there are two or more free-living crab instars before the invasive stage. The smallest "first stage females" found in oysters by Stauber were 1.4 mm. wide, and the smallest males were 1.5 mm.

Oyster crabs in Virginia oysters

No systematic study of the distribution, abundance, and effects of oyster crabs in Virginia has been made, but field notes accumulated by the Virginia Fisheries Laboratory give some data on these points. *Pinnotheres ostreum* has been found on all Virginia oyster grounds which have been observed. The percentage of oysters infested, on different oyster rocks, varies from less than 1 per cent to over 80 per cent, averaging around 30 or 40 per cent. Immature and mature female oyster crabs are found singly in Virginia oysters throughout the year. In only 5 of 276 infested oysters examined in 1943-44 were two crabs found in one oyster. Multiple infestations by male and female early-stage crabs, such as were described in New Jersey by Stauber (1942, 1945), were found only once in Virginia, at Cedar Island, James River, in the summer of 1945. Notes on females bearing sponges extend only from June through August, but the actual spawning season is probably much longer than this. *P. ostreum* zoeae have been found in plankton tows from June through August, but few tows were made in other months.

Significant damage to the gills of oysters by oyster crabs has been noted in many cases. Field notes on the condition of oysters generally show poorer condition in

EXPLANATION OF PLATE III

All drawings made with camera lucida from specimens killed and preserved in 5 per cent formalin, mounted in glycerine. Scale A represents 0.4 mm. in Figures 20, 22, and 23. Scale C represents 0.1 mm. in Figures 19 and 21.

FIGURE 19. Antenna of first crab instar, *P. ostreum*, drawn with $6 \times 44 \times$ lenses.

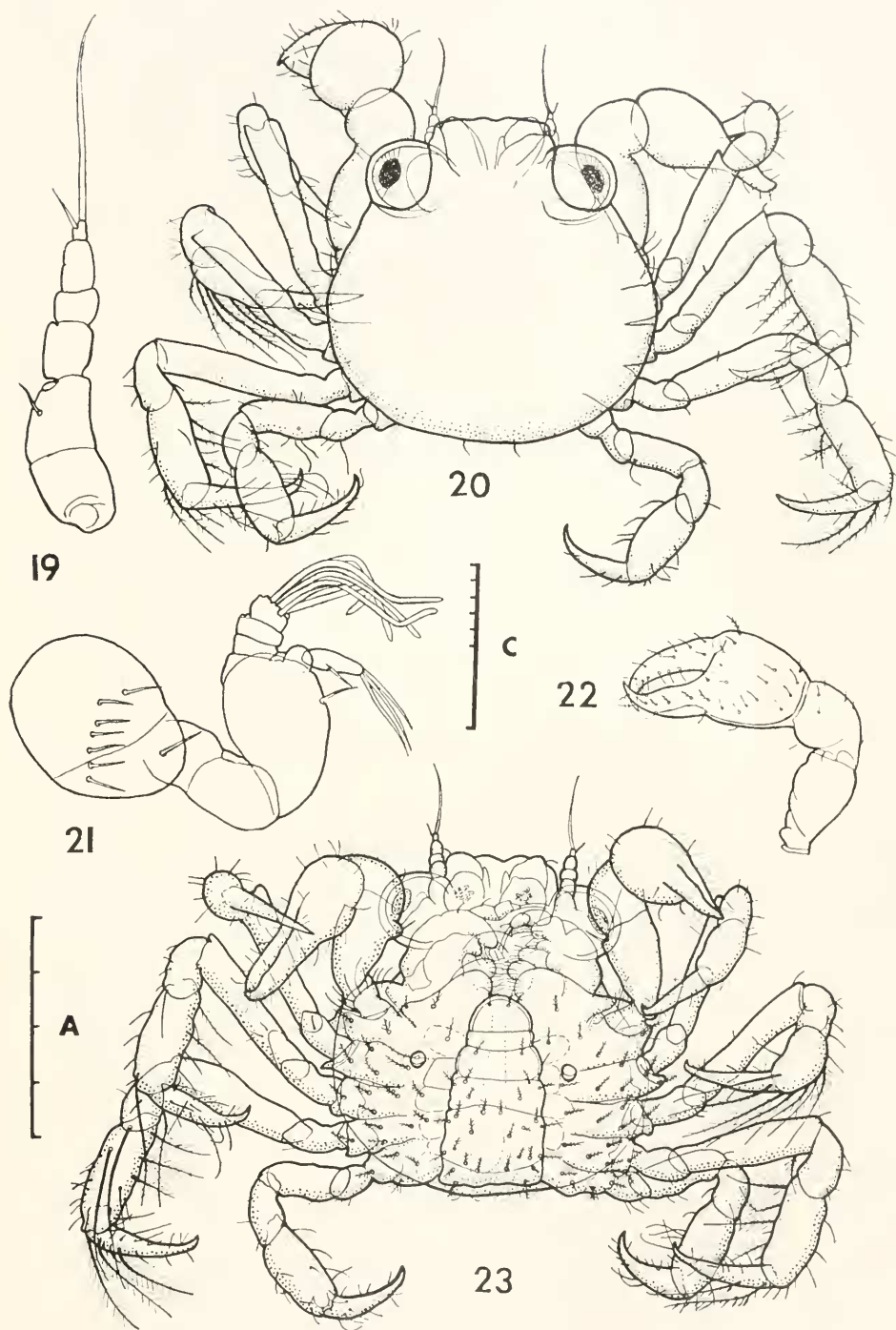
FIGURE 20. First crab instar, *P. ostreum*, reared in laboratory, dorsal view, pigment omitted, drawn with $10 \times 10 \times$ lenses.

FIGURE 21. Antennule of first crab instar, *P. ostreum*, drawn with $6 \times 44 \times$ lenses.

FIGURE 22. Right cheliped of first crab instar, *P. ostreum*, dorsal view, drawn with $10 \times 10 \times$ lenses.

FIGURE 23. First crab instar of *P. ostreum* reared from egg in laboratory, ventral view, drawn with $10 \times 10 \times$ lenses.

PLATE III



crab-infested than in uninfested oysters, but there are often some crab-infested oysters which show excellent condition. Miss Alice Elizabeth Overcash, in an unpublished thesis (1946) submitted to the College of William and Mary, has studied the "index of condition" of Virginia oysters, including many with oyster crabs. She reports that this index $\frac{(1000 \times \text{dry weight of meat in grams})}{(\text{Volume of shell cavity in milliliters})}$ averaged only 82.3 for crab-infested oysters in York River, compared to 90.6 for oysters without crabs. In Rappahannock River she found the mean index of oysters with crabs to be only 71.7, while the entire sample averaged 90.0. Both samples showed significantly poorer condition in infested oysters.

There seems to be no doubt that oyster crabs do injure oysters to some extent, but we have no evidence that they have ever caused the death of oysters in Virginia, as they did in the New Jersey outbreak reported by Stauber (1942, 1945).

SUMMARY

1. The early stages of *Pinnotheres ostrum* have been reared in the laboratory from the egg to the first crab.
2. There are four zoeal stages and one megalops stage. The four zoeal instars are distinguished by having 4, 6, 8, and 10 swimming hairs on the exopodites of both maxillipeds.
3. The time required for development from the early egg (from orange-colored egg mass) to the first crab instar was 38 days. From hatching to the first crab required 25 days.
4. The first crab being only 0.6 mm. wide, at least one more instar must intervene before *P. ostrum* reaches the "first stage" described by Stauber as the youngest crabs which invade the oyster.
5. Oyster crabs are widely distributed and abundant in Virginia waters. They tend to keep oyster meats in relatively poor condition, but have never been observed to cause mortality of oysters in Virginia.

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